XVIII. *Obſervations on a particular Manner of Increaſe in the Animalcula of vegetable Infuſions, with the Diſcovery of an indiſſoluble Salt ariſing from Hemp-ſeed put into Water till it becomes putrid.* *By* John Ellis, *Eſq*; *F. R. S.*

Read May 28, 1769. HAVING, at the requeſt of Dr. Linnæus, made ſeveral experiments on the infuſion of muſhrooms in water, in order to prove the theory of Baron Munchhauſen, that their ſeeds are firſt animals and then plants; which he takes notice of in his Syſtem of Nature, p. 1326, under the genus of *Chaos*, by the name of *Chaos fungorum ſeminum*: it appeared evidently that the ſeeds were put into motion by very minute animalcula which proceeded from the putrefaction of the muſhroom; for by pecking at theſe ſeeds, which are reddiſh, light, round bodies, they moved them about with great agility in a variety of directions, while the little animals themſelves were ſcarcely viſible, till the food they had eaten had diſcovered them. The ſatisfaction I received from clearing up this point led me into many other curious and intereſting experiments. I looked carefully over Mr. Turbervill Needham's, F. R. S. very ingenious memoir on this ſubject, vol. XLV. p 615, of the Philoſophical Tranſactions:

Tranſactions: I mean as to the experiments, many of which ſucceeded with me, ſome not*. I own, his

* The ingenious Mr. Needham ſuppoſes, thoſe little tranſparent ramified filaments, and jointed or coralloid bodies, which the microſcope diſcovers to us on the ſurface of moſt animal and vegetable infuſions when they become putrid, to be zoophytes or branched animals: but to me they appear (after a careful ſcrutiny with the beſt glaſſes) to be of that claſs of *Fungi* called *Mucor* or Mouldineſs, many of which Michelius has figured, and Linnæus has accurately deſcribed.

Their vegetation is ſo amazingly quick, that they may be perceived in the microſcope, even to grow and ſeed under the eye of the obſerver.

Mr. Needham has pointed out to us one that is very remarkable for its parts of fructification. See Phil. Tranſ. vol. XLV. Tab. v. fig. 3, *a*, A; this, he ſays, proceeded from an infuſion of bruiſed wheat.

I have ſeen the ſame ſpecies ariſe from the body of a dead fly, which was become putrid by lying floating for ſome time in a glaſs of water, where ſome flowers had been, in the month of Auguſt, 1768. This ſpecies of *Mucor* ſends forth a maſs of tranſparent filamentous roots, from whence ariſe hollow ſtems, that ſupport little oblong-oval ſeed veſſels with a hole on the top of each; from theſe I could plainly ſee minute globular ſeeds iſſue forth, in great abundance, with an elaſtic force, and turn about in the water as if they were animated.

Continuing to view them with ſome attention, I could juſt diſcover, that the putrid water, which ſurrounded them, was full of the minuteſt animalcula, and that theſe little creatures began to attack the ſeeds of the *Mucor* for food, as I have obſerved before in the experiment on the ſeeds of the larger kind of *Fungi* or muſhrooms. This new motion continued the appearance of their being alive for ſome time longer: but ſoon after many of them aroſe to the ſurface of the water, remaining there without motion; and a ſucceſſion of them afterwards coming up, they united together in little thin maſſes, and floated to the edge of the water, remaining there, quite inactive during the time of obſervation.

As this diſcovery had cleared up many doubts, which I had conceived from reading Mr. Needham's learned diſſertation, I

reaſoning is very ſpecious and plauſible, but too metaphyſical for a natural hiſtorian. Yet I cannot forbear relating one of the experiments which I tried in conſequence of his diſcovery, that animalcula were produced in various infuſions, notwithſtanding the greateſt heat was given to the liquor.

On the 25th of May, 1768, Fahrenheit's thermometer 70 degrees, I boiled a potatoe in New-river

put into the ſame glaſs ſeveral other dead flies, by which means this ſpecies of *Mucor* was propagated ſo plentifully, as to give me an opportunity of frequently trying the ſame experiment to my full ſatisfaction.

Laſtly, thoſe jointed coralloid bodies, which Mr. Needham calls chaplets and pearl necklaces, I have ſeen frequently very diſtinctly. Theſe appear not only on an infuſion of bruiſed wheat, when it becomes putrid, but on moſt other bodies, that throw up a viſcid ſcum, and are in a ſtate of putrefaction. Theſe then are evidently no more than the moſt common *Mucor*, the ſeeds of which are every where floating in the air; and bodies in this ſtate afford them a proper and natural ſoil to grow upon. Here they ſend downwards their fine tranſparent ramified roots into the moiſture which they float upon, and from the upper part of the ſcum their jointed coralloid branches riſe full of ſeed into little grove-like figures. When a ſmall portion of theſe branches and ſeeds are put into a drop of the ſame putrid water the ſcum floats upon, many of the millions of little animalcula, with which it abounds, immediately ſeize them as food, and turn them about with a variety of motions; as in the experiment on the ſeeds of the common muſhrooms; either ſingly or two or three ſeeds connected together, anſwering exactly to Mr. Needham's deſcription; but evidently without any motion of their own, and conſequently not animated.

I am ſatisfied Mr. Needham's obſervations have convinced him long before this, that they muſt be vegetables: for my part, I own I have never ſeen a zoophyte extend its branches, and grow out of water. I hope I have already cleared up that point, in ſhewing the abſurdity of Dr. Pallas's *Corallina terreſtris*, Phil. Tranſ. vol. LVII. p. 415.

water

water till it was reduced to a mealy conſiſtence. I put part of it, with an equal proportion of the boiling liquor, into a cylindrical glaſs veſſel that held ſomething leſs than half a wine pint, and covered it cloſe immediately with a glaſs cover. At the ſame time, I ſliced an unboiled potatoe, and, as near as I could judge, put the ſame quantity into a glaſs veſſel of the ſame kind, with the ſame proportion of New-river water, not boiled, and covered it with a glaſs cover, and placed both veſſels cloſe to each other.

On the 26th of May, twenty-four hours afterwards, I examined a ſmall drop of each by the firſt magnifier of Wilſon's microſcope, whoſe focal diſtance is reckoned at $\frac{1}{50}$th part of an inch, and to my amazement they were both full of animalcula of a linear ſhape, very diſtinguiſhable, moving to and fro with great celerity; ſo that there appeared to be more particles of animal than vegetable life in each drop.

This experiment I have repeatedly tried, and always found it to ſucceed in proportion to the heat of the circumambient air, ſo that, even in winter, if the liquors are kept properly warm, at leaſt in two or three days the experiment will ſucceed.

In Mr. Needham's experiments he calls theſe *ſpermatic animals*, Philoſophical Tranſactions, vol. XLV. p. 644 and 666; what I have obſerved are infinitely ſmaller than real ſpermatic animals, and of a very different ſhape; the truth of which every accurate obſerver will ſoon be convinced of, whoſe curioſity may lead him to compare them; and I am perſuaded he will find they are no way a-kin to that ſurprizing part of nature. And though ſome philo-

philoſophers of great reputation have agreed in ſentiment with Mr. Needham, yet I am ſatisfied, that whenever this ſubject is taken up again, and properly attended to, the world will be convinced they have been too haſty in their concluſions.

At preſent I ſhall paſs over many other curious obſervations, which I have made on two years experiments, in order to proceed to the explaining a hint, which I received laſt January from Mr. De Sauſſure, of Geneva, when he was here; which is, that he lately found one kind of theſe *animalia infuſoria*, that increaſes by dividing acroſs into nearly two equal parts.

I had often ſeen this appearance, in various ſpecies, a year or two ago; as I found upon looking over the minutes I had taken when I made any new obſervation; but always ſuppoſed the animals in this dividing ſtate to be in coition.

Not hearing till after Monſieur De Sauſſure had left this kingdom, from what infuſion he had made his obſervation; his friend, Doctor De la Roche, of Geneva, informed me, the latter end of February laſt, that it was from hempſeed.

I immediately procured hempſeed from different ſeedſmen, in diſtant parts of the town: ſome of it I put into New-river water, ſome into diſtilled water, and ſome I put into very hard pump-water; the reſult was, that in proportion to the heat of the weather, or the warmth in which they were kept, there was an appearance of millions of minute animalcula in all the infuſions; and ſome time after, ſome oval ones made their appearance, as at TAB. VI. Fig. 1. *b. c.* Theſe were much larger than the firſt, which ſtill continued;

nued; theſe wriggled to and fro in an undulatory motion, turning themſelves round very quick, all the time that they moved forwards. I was very attentive to ſee theſe animals divide themſelves; and at laſt I perceived a few of the appearance of Fig. 1. *a.*, as it is repreſented by the firſt magnifier of Wilſon's microſcope; but I am ſo well convinced by experience, that they would ſeparate, that I did not wait to ſee the operation: however, as the following ſketches, which I have drawn from five other ſpecies, will very fully explain this extraordinary phænomenon, there will be no difficulty in conceiving the manner of the firſt. See Fig. 2, 3, 4, 5, and 6.

The proportion of the number of the animals, which I have obſerved to divide in this manner, to the reſt, is ſcarce 1 to 50: ſo that it appears rather to ariſe from hurts received by ſome few animalcula among the many, than to be the natural manner in which theſe kind of animals multiply: eſpecially if we conſider the infinite number of young ones which are viſible to us through the tranſparent ſkins of their bodies, and even the young ones that are viſible in thoſe young ones, while in the bodies of the old ones.

But nothing more plainly ſhews them to be zoophytes than this circumſtance; that when, by accident, the extremity of their bodies has been ſhrivelled for want of a ſupply of freſh water, the applying more freſh water has given motion to the part of the animal that was ſtill alive; by which means this ſhapeleſs figure has continued to live and ſwim to and fro all the time it was ſupplied with freſh water.

I cannot finiſh this part of my remarks on theſe animals, without obſerving, that the excellent Linnæus

næus has joined the *heroe* with the *volvox*, one of the *animalia infuſoria*. The *heroe* is a marine animal found on our coaſts, of a gelatinous, tranſparent nature, and of an oval or ſpherical form, about half an inch to an inch diameter, divided like a melon into longitudinal ribs, each of which is furniſhed with rows of minute fins, by means of which this animal, like the *animalia infuſoria*, can ſwim in all directions with great ſwiftneſs. In the ſame manner I have ſeen moſt of theſe minute animals, which move ſo ſwift that we could not account for it, without ſuppoſing ſuch a proviſion of nature, which is really true; but cannot be ſeen till the animals grow faint for want of water; then, if we attend, we may, with good glaſſes, plainly diſcover them *.

I come now to a ſingular property, which I have diſcovered in hempſeed, of producing an indiſſoluble

* I have lately found out, by meer accident, a method to make their fins appear very diſtinctly, eſpecially in the larger kind of animalcula, which are common to moſt vegetable infuſions, ſuch as the *Terebrella*: this has a longiſh body, with a cavity or groove, at one end, like a gimblet: by applying then a ſmall ſtalk of the horſe-ſhoe *Geranium* (or *Geranium zonale* of Linnæus), freſh broken, to a drop of water in which theſe animalcula are ſwimming, we ſhall find, that they will become torpid inſtantly, contracting themſelves into an oblong-oval ſhape, with their fins extended like ſo many briſtles all round their bodies; the fins are in length about half the diameter of the middle of their bodies. Before I diſcovered this expedient, I tried to kill them by different kinds of ſalts and ſpirits; but though they were deſtroyed by this means, their fins were ſo contracted, that I could not diſtinguiſh them in the leaſt. After lying in this ſtate of torpidity for two or three minutes, if a drop of clean water is applied to them, they will recover their ſhape, and ſwim about immediately, rendering their fins again inviſible.——For the different ſtates of this animalcule, ſee TAB. VI. Fig. 5. *a*, *b*, *c*, *d*.

ſalt,

ſalt, when infuſed for ſome time in water: and as hempſeed is known to be an efficacious medicine in ſome particular caſes, theſe experiments may demand a ſtricter enquiry from the profeſſors of phyſic, which may poſſibly turn to the benefit of mankind.

Experiment I.

On the 25th of February laſt, I put half an ounce of hempſeed to about two ounces of New-river water in a vial, and covered it cloſe with paper, to prevent the duſt coming to it: by the 25th of March it became very putrid, and had thrown up a viſcid ſcum to the top. Fahrenheit's thermometer in the houſe was, during this time, from about 44 to 52 degrees. I examined this ſcum with a common magnifier, of about an inch focus, and could diſcover it to be full of regular-ſhaped ſalts, which lay on the ſurface; ſome of a ſquare, others of an oblong figure.

Applying ſome of the ſcum to a ſlip of glaſs, I placed it in the ſingle or Wilſon's microſcope, making uſe of the fourth magnifier, and it exhibited the cryſtals repreſented before fig. 7; but as the ſtirring of the ſcum had obſcured the preciſe figure of the ſalts, I applied a hair pencil to them, dipt in clean river water, and ſeparated them from the mucilage that had beſmeared them; yet, notwithſtanding this addition of water, their figures were not in the leaſt impaired or melted, but their outlines were rather more exactly defined. Nor were the millions of mi-

nute animals that were ſwimming over them, and all round them, in the leaſt affected by the ſalt *.

I further obſerved, that the cryſtals that appeared firſt increaſed in ſize, and began to vary their forms; for inſtance, many of the cryſtals, at the latter end of April, among the reſt, were of the form of thoſe in the line of fig. 8. About the 5th of May, many of them appeared as at fig. 9; and at the latter end of May, about the 20th, many of them were of the form of thoſe at fig. 10: moſt of the variety of forms appearing at the ſame time.

It was objected by ſome very ingenious men, to whom I had imparted this diſcovery, that theſe ſalts might be owing to ſomething in the water that I had made uſe of, which, joined to the oil in the hemp-ſeed, might produce this appearance. To obviate this:

Experiment II.

I prevailed on my friend, Mr. P. Woulfe, F. R. S. to furniſh me with ſome water that had been moſt carefully diſtilled, by a very ſlow proceſs; and at the ſame time I procured hempſeed from a different part of the town, On the 30th of April, I put an ounce of this hempſeed to about four ounces of this diſtilled water, into a glaſs cylindrical veſſel, and covered it carefully with a glaſs cover; and on the 12th of May I examined the ſcum, and found it more tranſparent,

* Mr. Needham obſerves, in his curious Memoir before mentioned, p. 649, that ſalt deſtroys theſe animalcula; this, I believe, is very true of the common kinds of ſalt; and which renders the nature of this kind of ſalt ſtill more ſingular.

but

but full of the cryſtals of ſalts, as repreſented at fig. 12. Some of the firſt hempſeed put into the ſame water produced much ſalt, but not ſo regular in its figures; theſe figures, by ſome means unknown to me, after their cryſtallization being broke irregularly at their ends, ſee fig. 13. But yet in this infuſion there were many of the original ſeminal figured ſalts.

EXPERIMENT III.

I was determined to ſee what effect the hard pump water of Gray's-Inn, after a month's dry weather, would have on the hempſeed in infuſion; particularly as I was perſuaded from experience, that this water contained a large portion of calcareous earth. Accordingly, on the 5th of May, I put an ounce of the ſame hempſeed with the laſt which I had obtained, into four ounces of this pump water; and on the 17th of May I perceived the cryſtals, which, on being put into the microſcope, with the ſame magnifier, gave the appearance repreſented at fig. 14.

The cryſtals of this infuſion ſeemed larger and flatter, and ſomething different in their ſhape; but on examining the mucilage that lay among the ſeeds at the bottom of the glaſs, I found an infinite number of the ſame ſhaped cryſtals with thoſe I have called ſeminal cryſtals; which were likewiſe found in the mucilage of the New-river water infuſion, and in the diſtilled water infuſion among the ſeeds.

I muſt further obſerve, that the calcareous earth floated in great abundance among the ſcum of the pump-water, as ſoon as the putrefaction was ad-

vanced; which did not appear on the ſurface of the diſtilled water, and ſcarcely any on the river water.

The grains of ſalt produced in theſe experiments were about the ſize of the fineſt baſket ſalt, and of a pale yellowiſh colour when dry.

Gray's-Inn,
May 24, 1769.

POSTSCRIPT.

I have ſince found the ſame kind of cryſtals in an infuſion of flax-ſeed in New-river water, and alſo in wheat that has been infuſed in boiling hot water; but the cryſtals were fewer, and did not appear ſo ſoon in the flax-ſeed as in the hemp-ſeed. And the experiment of wheat infuſed in boiling hot water does not always ſucceed.

I have likewiſe found ſalts not unlike thoſe of the hempſeed, in infuſions of a variety of pulſe and grain from the Eaſt Indies, ſuch as lupines, kidney-beans, vetches, millet, Guinea-corn, and the ſeſamum or oily grain: but the laſt yielded a much larger quantity of ſalt, and in a ſhorter time, than any of the reſt.

The ſalts of theſe different ſubſtances were alſo not diſſolvable upon applying clean water to them; but by letting the infuſions continue to putrefy ſome weeks longer, they by degrees aſſumed irregular ſhapes, and diſappeared. I muſt conclude, then, with this quere, Are not theſe the oily parts of the vegetables, which float in the ſcum, on the ſurface of the infuſion, cryſtallized?

Explana-

Explanation of the FIGURES, TAB. VI.

Theſe five different kinds of *animalia infuſoria*, belonging to the genus of *Volvox* of Linnæus, are here repreſented both in their perfect and in their divided ſtate. The trivial names are added to diſtinguiſh the ſpecies.

Fig. 1. repreſents the *volvox ovalis*, or egg-ſhaped volvox: at (*c*) and (*b*) it is expreſſed in its natural ſhape: at (*a*) the manner in which it becomes two animals, by ſeparating acroſs the middle: this was found in the infuſion of hempſeed, but is found in other vegetable infuſions, particularly in that of teaſeed.

Fig. 2. is the *volvox torquilla*, or wryneck. At (*a*) is repreſented its divided ſtate, at (*b*) and (*c*) its natural ſhape; this is common to moſt vegetable infuſions, as is the following.

Fig. 3. is the *volvox volutans*, or the roller. At (*a*) the animal is ſeparated, and becomes two diſtinct beings, each ſwimming about and providing for itſelf; this is often the prey of another ſpecies of this genus, eſpecially while it is weak by this ſeparation, not being ſo active for ſome time till it can recover itſelf. At (*c*) the animal appears to be hurt on one ſide; this impreſſion, in a little time, is ſucceeded by another on the oppoſite ſide, as at (*b*), which ſoon occaſions a diviſion.

At

At (*d*) is the ſide view, and at (*e*) the front view of the natural ſhape of the animal.

Fig. 4. is the *volvox oniſcus*, or wood-louſe. At (*a*) is the natural ſhape of it, as it appears full of little hairs both at the head and tail; with thoſe at the head it whirls the water about, to draw its prey to it; the feet, which are many, are very viſible, but remarkably ſo in a ſide view at (*d*). At (*b*) it is repreſented beginning to divide, and at (*c*) the animals are ready to part: in this ſtate, as if in exquiſite pain, they ſwim round and round, and to and fro, with uncommon velocity, violently agitated till they get aſunder. This was found in an infuſion of different kinds of pine branches.

Fig. 5. is the *volvox terebrella*, or the gimblet. This animal is one of the largeſt of the kind, and is very viſible to the naked eye. It moves along ſwiftly, turning itſelf round as it ſwims, juſt as if boring its way. (*a*) and (*b*) are two views of its natural ſhape. (*c*) ſhews the manner of its dividing. When they are ſeparated, the lower animal rolls very aukwardly along till it gets a groove in in the upper part. (*d*) repreſents one of them lying torpid, by means of the juice of the *horſeſhoe geranium*, with its fins extended. This animal is found in many infuſions, particularly of graſs or corn.

Fig. 6. is the *volvox vorax*, or the glutton. This animal was found in an infuſion of the Tartarian pine; it varies its ſhape very much, contracting

Contracting and extending its proboſcis, turning it to and fro, in various directions, as at *a*, *b*, *c*, *d*, *e*. It opens its proboſcis underneath the extremity, when it ſeizes its prey. The leſs active animals, that have lately been divided, ſuch as thoſe at Fig. 2. *a*. and Fig. 3. *a*, ſerve it as food when they come in its way: theſe it ſwallows down inſtantly, as it is repreſented at Fig. 6. *h*. and *i*. At (*f*) it is ready to divide, and at (*g*) it is divided, where the hinder part of the divided animal has got a proboſcis or beak, to procure nouriſhment for itſelf, and ſoon becomes a diſtinct being from the fore-part.

Fig. 7. repreſents the appearance of the ſalts in hempſeed, after a month's infuſion, from the 25th of February to the 25th of March, in New-river water.

Fig. 8. The ſalts, about a month after, April 25, appeared in this manner.

Fig. 9. Theſe figures repreſent them about the 5th of May, or ten days after.

Fig. 10. About the 20th of May, they exhihited the figure of precious ſtones.

Fig. 11. Theſe I have called ſeminal ſalts, as theſe ſmall figures are to be ſeen in moſt of the infuſions, riſing at different times, and exhibiting theſe ſhapes, when they firſt appear diſtinctly,

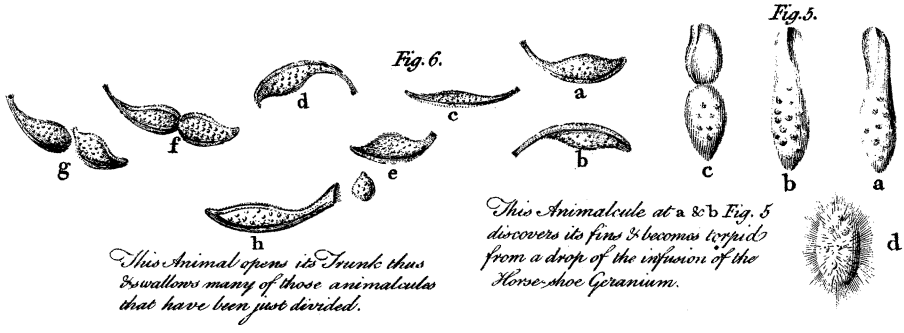
Fig. 12. repreſents the ſalts of hempſeed in diſtilled water, that had been infuſed from the 30th of April to the 12th of May.

Fig.

Fig. 13. ſhews the form of the ſalts when the putrefaction had begun to ſeparate their parts into laminæ in the diſtilled water.

Fig. 14. are the figures of the ſalts that appeared from the hempſeed, infuſed in hard pump-water about twelve days, from the 5th of May to the 17th.

The Figures of 6 kinds of Animalcula infusoria, that encrease by dividing across the middle into two distinct animals.



This Animal opens its Trunk thus & swallows many of those animalcula that have been just divided.

This Animalcule at a & b Fig. 5 discovers its fins & becomes torpid from a drop of the infusion of the Horse-shoe Geranium.

Figures of Salts, not dissolvable in Water, arising from a putrid infusion of Hempseed.